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LOAD CHARACTERISTICS ANALYSIS OF DRONE USING LOAD CELL AND MEMS SENSOR

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ABSTRACT

The effects of dynamic stability of the quadrotor Unmanned Aerial Vehicle, such as cornering, wear and explosion of oar took place due to the aerodynamic force and effects of gyroscope during the time of takeoff and landing process; the vibrations in the drone could get out of control due to the influence of turbulence in atmosphere and motion coupling effects during yawing. However, the improved structural parameters of an aircraft are very important for developing the stability of the motion control and energy saving. Therefore, the affiliation of quantification between the structural parameters of quadrotor UAV and dynamic stability is built starting from the design of the structure test bed, which guides the mechanical-structural design and provides the vital base for optimizing the control system.

KEYWORDS: Quadcopter, Unmanned Aerial Vehicles, Accelerometer, Thrust level & Drone

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Original Article

1. INTRODUCTION

Quadcopters are a little rotating specialties that can be utilized in different situations, where they can keep up float capacities like a regular helicopter, however, are precisely less complex and can accomplish higher mobility. They utilize four fixed pitch propellers to control lift and a mix of propeller torques to control move, pitch and yaw. In this work, the quadrotor will be created as a UAV (Unmanned Aerial Vehicle) which does not require a locally available pilot. UAVs are normally planes and helicopters which have been furnished with PC control so as to perform self-governing or semi-self-ruling undertakings.

2. OBJECTIVE

In this venture, we have utilized MEMS accelerometers against the ordinary accelerometers in order to minimize the overall expense and make a progressively dependable framework.[1] MEMS is an empowering innovation which permits scaling down of existing gadgets, to offer arrangements which cannot be accomplished by miniaturized scale machined items. MEMS enables the complex electromechanical frameworks to be produced by diminishing the expense and expanding the unwavering quality. It permits incorporated frameworks, sensors, actuators, circuits and so on in a solitary bundle and offers favorable circumstances of dependability, execution, cost, usability and so forth. This innovation is being used generally to produce cutting edge MEMS-based accelerometers. [2]

First MEMS accelerometers utilized piezo resistors. Not with standing, piezo resistors are less touchy than capacitive identification. The vast majority of the MEMS accelerometer utilize capacitive detecting guideline.

3. PROBLEM DEFINITION

Using the attitude estimates that are calculated from the four accelerometers, a fully autonomous quadrotor can be a possibility in the near future. It can also be used to maneuver the quadrotor in terrains, where humans and ground robots cannot access when it is made autonomous, as it can maneuver on its own. Further improvements can also be made to make the quadrotor avoid obstacles and tuning for improving the performance during aggressive maneuvers.

4. EXPERIMENTAL SETUP

The setup of our experiment comprises of quadcopter fixed on a Novapan. Load cells have been attached by means of cables to each corner of the quad. The accelerometer is fixed on four arms of the quad to test the angle of deflection. The load cell and accelerometer are connected to the interface base, which is also called foam board. The load cell and accelerometer are connected with the help of I2C wire, which gives 8-bit information to the interface board. WiFi modem is placed on the interface base, through which the required output is obtained in the blink app. This app provides deflection of the propellers in various angles in the form of a graph, also the average load on a particular angle is displayed in it.[3]

5. TESTING PROCEDURE

The quadcopter is first checked for basic stability by placing it on the Novapan. The battery is connected to the quad to give the required power to operate. Separate HW battery is connected to WiFi modem to provide the power to operate. Once all connections are checked, setup is ready to test.

Using remote controller, the quad is switched on. Deflections in the graph indicate the readings on base point. The propellers are adjusted to move the deflection in the graph indicating the angle to which they have deflected and also the average load acting on the Novapan by the quad is displayed. This setup is a prototype of stability tester. By this setup, we are here to calculate the average amount of load in a particular angle of deflection made by the quad.

Figure 1: Multi Rotor Drones.

Figure 1 displays unlike single and double rotor helicopters which are used as complex variable pitch rotors, whose pitch varies as the blade rotates for flight stability and control. Multirotor often uses fixed pitch blades control of vehicle motion, which is achieved by changing the relative speed of each rotor to convert the thrust and torque produced by each.

Out of all the four drone types (based on aerial platform), multirotor drones are simple to manufacture and they are the less expensive ones available and to choose from as well. Multirotor drones can be further divided based on the number of rotors on the platform. They are tricopter, quadcopter and hexacopter and octocopter. Out of these, quadcopters are the most popular and widely used variant.

Although the technology is developing all the time, multirotors are basically very inefficient and need a lot of energy just to fight gravity and keep them in the air. With current battery technology, they are limited to around 20–30 minutes when carrying a less weight camera payload.

Overwhelming lift multirotors are established for conveying more weight, yet in return for a lot of shorter flight times. Because of the requirement for speed and high-exactness throttle, changes to keep them balanced out, is not functional to use as a gas motor to control multi-rotors, so they are limited to electric engines. In this way, until another power source tags along, we can just anticipate little gains in the flight times.

6. FIXED WING DRONES

Fixed wing rambles are one of the sorts of automatons that uses the same rule that planes use to produce lift utilizing a wing other than the vertical push creating rotors. The vertical lift is generated as an outcome of the forward movement of the wing through the air, making this an increasingly proficient method for creating vertical lift.

Figure 2: Fixed Wing Drones.

Figure 2 displays that they used 'wings' like the natural planes out there. Dissimilar to multirotor rambles, fixed-wing-type models were not used vitally to remain above water on air (fixed wing types cannot stop reporting in real time) battling gravity. Rather, they push ahead on their set course or as set by the guide control (conceivably a remote unit worked by a human) as long as their vitality source licenses. Thus, they can cover very long distances, map a lot of bigger regions and saunter for long occasions, checking their focal point. Not maintaining the more prominent productivity, it is additionally conceivable to use gas motors as their capacity source, and with the more noteworthy vitality thickness of fuel, many fixed-wing UAVs can remain high for 16 hours or more.

7. SINGLE ROTOR HELICOPTER

Single rotor rambles look basically the same as in plan and structure to real helicopters. While a multirotor has a wide range of rotors to hold it up, in contraction to a tail rotor to control its heading. Helicopters are famous in keeping an eye on a flight, however, at present, just fill a little specialty in the automation world.

Figure 3 displays that solitary rotor helicopter has the advantage of a lot more prominent proficiency over a multi rotor, and furthermore, they have higher flying occasions and can even be controlled by gas motors.

Figure 3: Single Rotor Helicopter.

This is because quad-copter is more efficient than an octocopter and unique long durability quads have an equivalent propeller distance across. In the event that the application needs drifting, a huge payload for example, a LIDAR scanner, or you need a mix of long continuous with sending flight. At that point, a solitary rotor helicopter ramble is impeccable. Drifting a helicopter ramble over a given spot is generally straightforward, and the forward flight aptitudes can be learned as you proceed. In any case, helicopter rambles are quite unsteady while flying and need great abilities to keep it noticeable all around. They additionally require a progressively mechanical support because of their expanded multifaceted nature.

8. FIXED WING HYBRID VTOL

Another classification of cross breed rambles that can take off and land vertically are being created. These consolidations are the advantages of fixed-wing UAVs with the capacity to drift.

There are varieties of sorts at work in progress, some of which are basically simply existing fixed-wing plans with vertical lift engines darted on. Others are 'tail sitter' airplane, which resemble a customary plane; however, lay on their tails on the ground, pointing straight up for takeoff before pitching over to fly typically, or 'tilt-rotor' types, where the rotors or even the entire wing with propellers appended can swivel indicating upward motion for departure, pointing at a level plane for sending flight.

This idea has been encountered from around the 1960s, but considerable achievement in this regard has been absent. A reasonable number of the experimental drill have met with appalling outcomes. Be that, as it may, with the coming of advanced sensors (gyros and accelerometers), this idea has got some new life and course. Half breed VTOLs are a play of mechanization and manual skimming. A vertical lift is used to lift the automation, which is very high from the beginning. gyros and accelerometers work in mechanized mode (autopilot idea) to keep the automaton settled noticeably all around. Remote-based (or even modified) manual control is used to direct the automaton on the ideal course.

As of now, there are just a bunch of half and half fixed wings, which are available and accessible. Be that, as it may, you can hope to see a large amount of these kinds of structures as innovation progresses. One case of this sort of configuration is Amazon's Prime Air conveyance ramble.

Figure 4: Fixed Wing Hybrid VTOL.

7. OUTLINE OF THE UAV TEST-BED

The initial step in designing and building the UAV test-bed was to create a software environment that can be used for simulation purposes. The test-bed uses I2 C (inter-integrated circuit). There are four load cells and four accelerometers being used. The accelerometers which are used as the ADXL345. This is a MEMS Accelerometer. There are four load cells used in the testbed. The strain gauge type of load cell was implemented.

There are totally two bases used. One of the bases is quadcopter and the other base is for the interface board. The quadcopter specifications are as follows:

Table 1: Quadcopter Specifications

Motor used	2300 kV
Diagonal Length	210 mm
Flight Time	5 minutes
Weight	750 gms (without battery)
Propeller Material	Plastic
The thrust produced per Motor	500 N
Total Thrust produced	2000 N
Battery Storage	2200 mAh

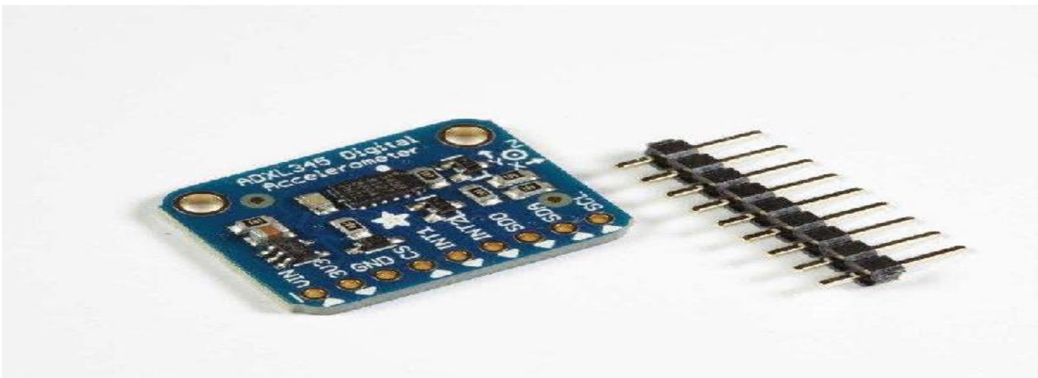

Figure 5: ADLX Accelerometer.

Figure 5 displays that the ADXL345 consists of a 3-hub MEMS accelerometer modules, which has low power with I2C and SPI interfaces. The Arduino is utilized to make the Adafruit breakout sheets and for these segments locally available 3.3 V voltage guideline and ever-changing level included makes it easy to interface with microcontrollers 5 V.

The ADXL345 highlight has 4 affectability reaches from +/ - 2 G to +/ - 16 G. Also, it holds yield information rates extending from 10 Hz to 3200 Hz.

8. MEMS – MICRO-ELECTRO-MECHANICAL SYSTEMS

This sensor contains a miniaturized scale machined structure on a silicon wafer. The structure is encountered by polysilicon springs, which enable it to divert easily toward any path when subjected to quickening in the X, Y as well as Z hub. Due to the deflection, it causes an adjustment in capacitance between both fixed plates and plates appended to the suspended structure. On every pivot, the adjustment in capacitance is changed over to a yield voltage corresponding to the increasing speed on that hub.

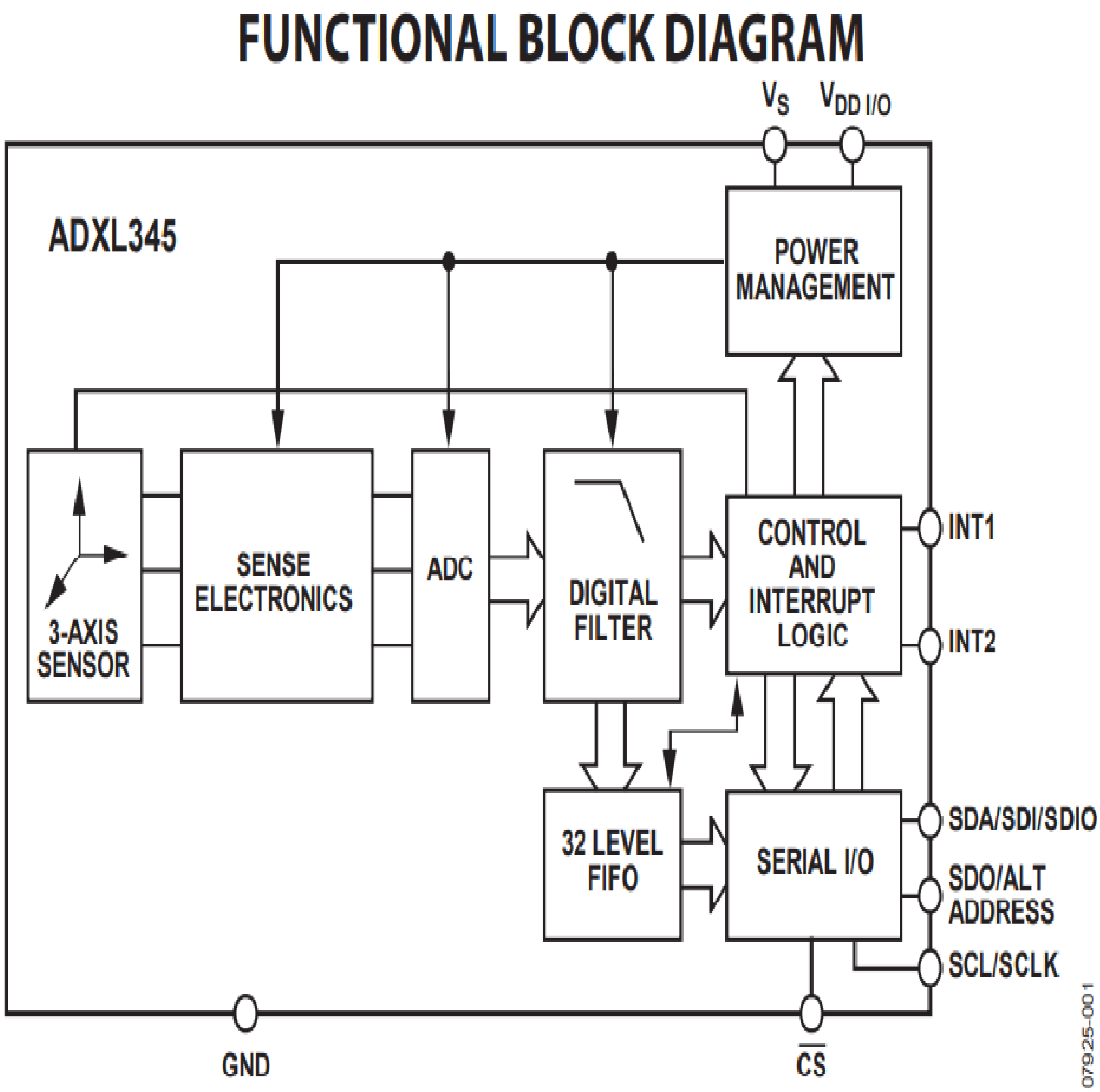

Figure 6: Functional Block Diagram.

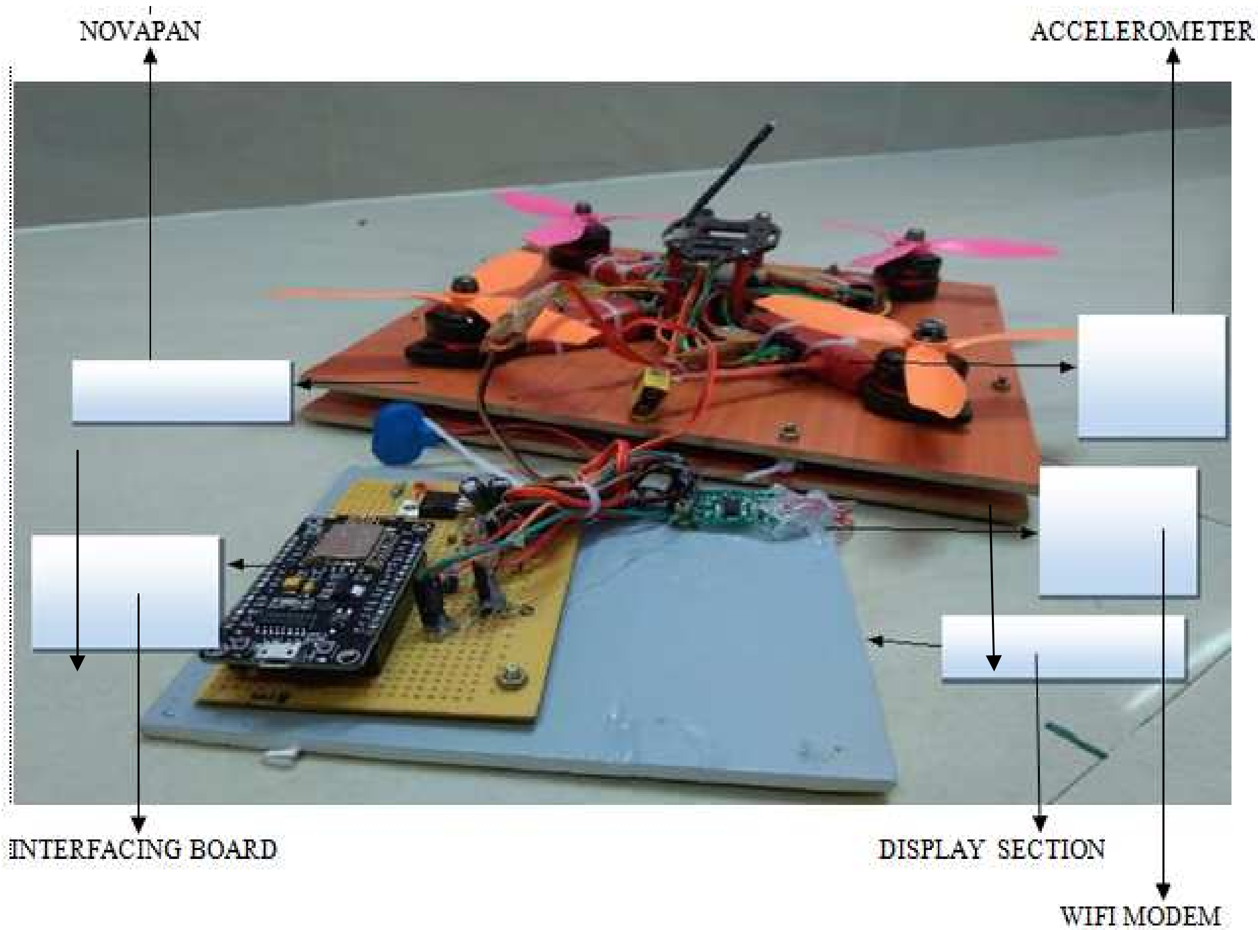

Figure 7: Load Cell Accelerometer.

Figure 7 displays that the setup of our experiment comprises of quadcopter fixed on a Novapan. Load cells have been attached by means of cables to each corner of the quad. The accelerometer is fixed on four arms of the quad to test the angle of deflection. The load cell and accelerometer are connected to the interface base (also called the foam board). The load cell and accelerometer are connected with the help of I2C wire which gives 8-bit information to the interface board. WiFi modem is placed on the interface base by which the required output is obtained in the blink app. This app displays deflection of the propellers in various angles in the form of the graph, also the average load on a particular angle is displayed in it.

9. RESULTS AND DISCUSSIONS

Figure 6 displays the quadcopter has been tested with the support of test bed. The testbed describes the concept of a highly flexible distributed testbed to support the analysis, test, evaluation and demonstration of advanced data processing. For angle of deflection, graphs have been plotted using the application of Blink Software. The graphs have been plotted to calculate the average amount of load in particular angle of deflection made by the quadcopter. The graph has been plotted using the accelerometer readings.

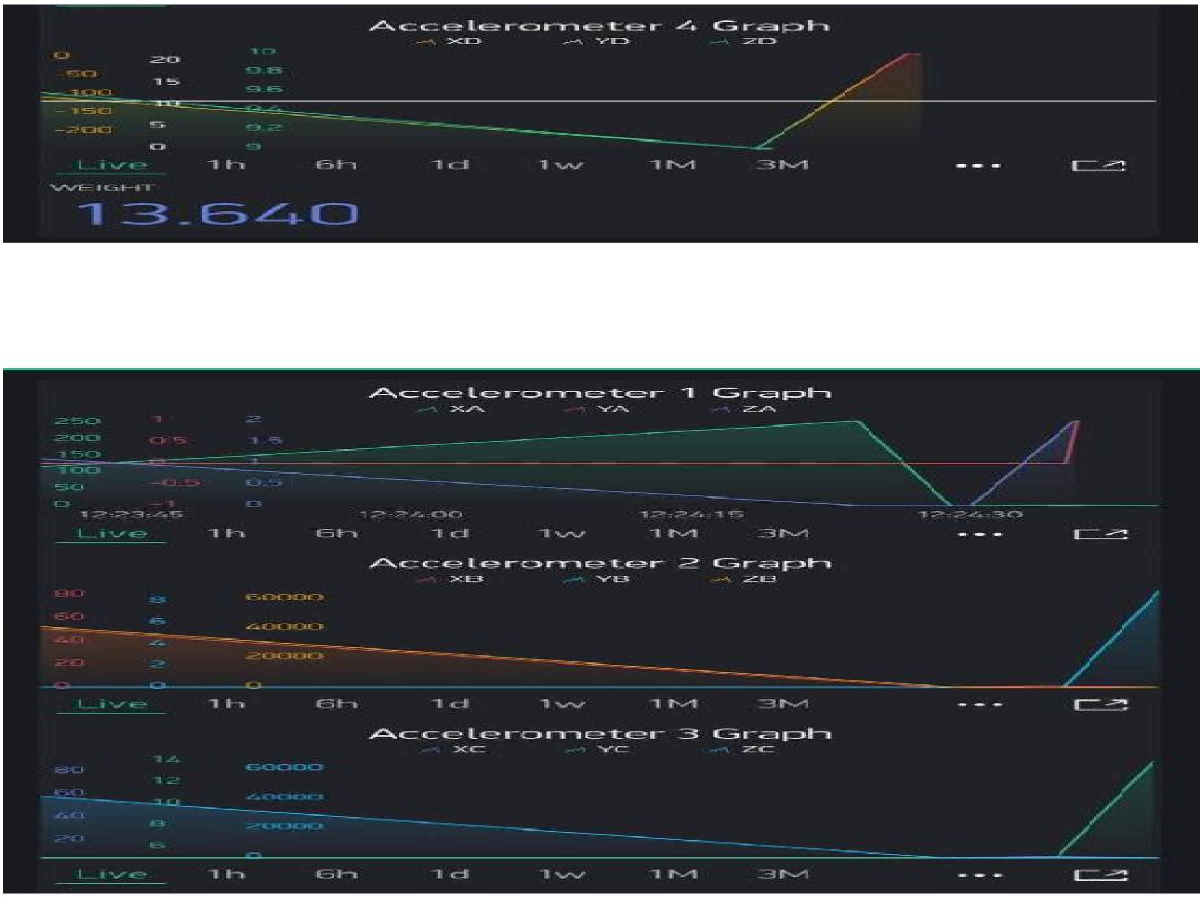

Figure 8: Amount of Load by Accelerometer.

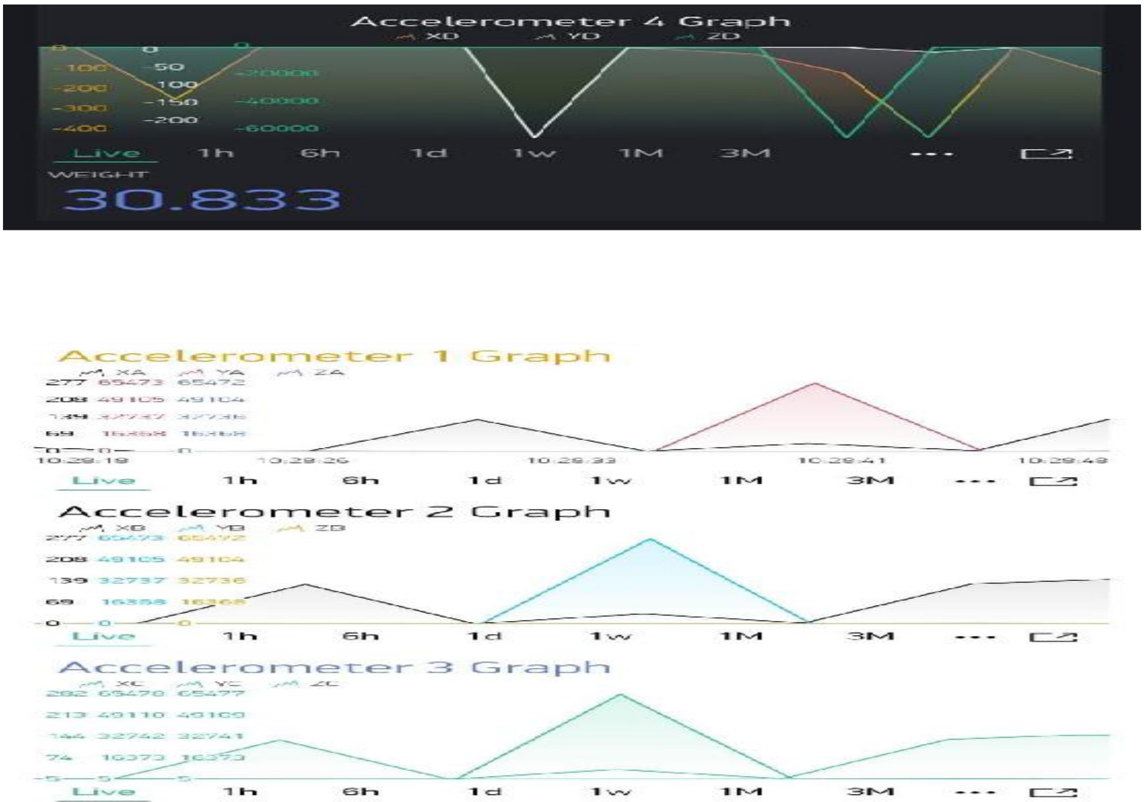

Figure 9: Accelerometer Graph.

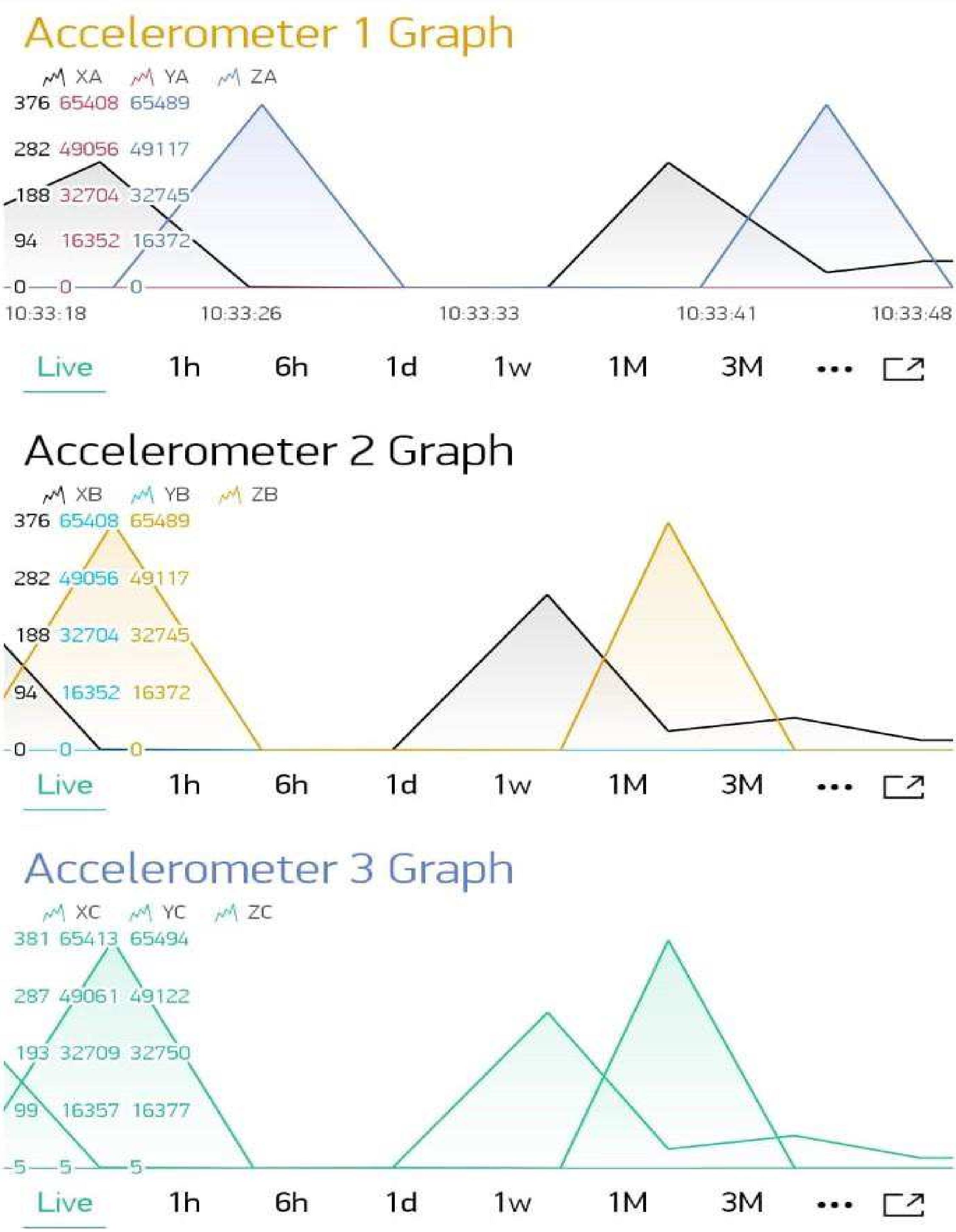

Figure 10: Accelerometer Graph.

Table 2

Various Attitude	Total Average Weight
ROLL Right	19.20
ROLL Left	20
PITCH Forward	19.91
PITCH Backward	23

10. CONCLUSIONS

After configuring all the parts, assembling as required, configuring the software, the graphs are plotted for each accelerometer, total load is calculated. The peaks in each graph indicate the maximum point up to which the quadcopter can be deflected. Above this point, if thrust is still applied, the quadcopter tends to drift away, leading to stability problems.

Each graph also gives the value of average load acting with respect to the attitude of the quadrotor at a given RPM. If the quadrotor experiences more than the given weight, it will cause structural failure. These two parameters are some of the many parameters that need to be taken into account while developing autonomous drones. Because of the fast dynamics of the quadrotor, it requires frequently updated position, orientation and other such parameters. Also, the maximum payload that a quadrotor can carry poses a problem for the number of sensors that can be used. It is clear that timely updates of attitude and velocity in particular help in creating a completely autonomous quadrotor. So, with this project, we show how attitude estimates can benefit from the traditional model of the quadrotor. Also, the load determination is calculated with respect to angle of deflection.

11. FUTURE ENHANCEMENT

The future of a quadcopter is based on different applications. The maximum development of automated quadcopters in terms of their distance covered and increase in their widespread applications also determine their commercialization prospects. Quadrotors are ideal for autonomous flight in unfamiliar and critical. The small size and maneuverability of quadrotors enable them to do so. There are numerous sensors that can be fitted on to a quadrotor, which makes it more feasible than applications performed by ground robots.

The quadrotors' small size and maneuverability also prevent them from being fully autonomous. The fast dynamics of the quadrotor requires frequent position updation, orientation and other such parameters. Also, the maximum payload that a quadrotor can carry poses a problem for the number of sensors that can be used.

It is clear that the timely updates of altitude and velocity, in particular, help in creating a completely autonomous quadrotor. So, with this project, we show how attitude estimates can benefit from the traditional model of the quadrotor. Also, the load estimate is calculated with respect to angle of deflection.

So, with the help of MEMS accelerometers, the development of autonomous quadcopters can be made possible.

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Stanley Samlal received the B. E. degree in Mechanical from Anna University in 2010 and M.E. degree in Aeronautical from Hindustan Institute of Technology and Science in 2012. He is actively involved in the testing and research on sandwich composites and structures in impact damage and damage assessment work at the Structural Impact and Crash Simulation Centre (SIMCRASH), Hindustan Institute of Technology and Science, Chennai, India. He has conducted research in the areas of mechanics, fracture, longevity, damage resistance, and damage tolerance of composite materials and their structures. The work has an experimental orientation, but development of analytical tools has also been pursued with a particular objective of developing efficient analytical methodologies which are useful in performing parametric studies early in the design process. He has published on these topics and on general topics related to composite materials and their structures. He has taught courses in the areas of Composite materials, Aero Engineering Thermodynamics, Heat transfer in Materials, High temperature materials and Experimental Stress Analysis with special emphasis on material science and their structures. He has developed courses dealing with impact mechanics, manufacturing composite materials and advanced topics in composite materials and structures. He is an Associate Member (AM) of the AeSI.